California Integrated Waste Management Board
Recycling and Waste Management Infrastructure Project

Approach to Waste Flow and Infrastructure Modeling

January 30, 2009

In addition to an inventory of waste management and recycling facilities, the Recycling and Waste Management Infrastructure Project (Infrastructure Project) Web Site will also provide model projections for waste generation and infrastructure needs based on assumed scenarios. The model results are intended to be suitable for broadly estimating the need for new facilities by region. However, the model results are not intended to provide detailed analysis sufficient to support planning, design, or financing of specific facilities. Such implementation oriented activities will require detailed analysis specific to companies, sites and markets that is beyond the scope of this project.

This paper presents a preliminary approach to modeling and describes how users of the Infrastructure Information Web Site may be able to access and use model results.

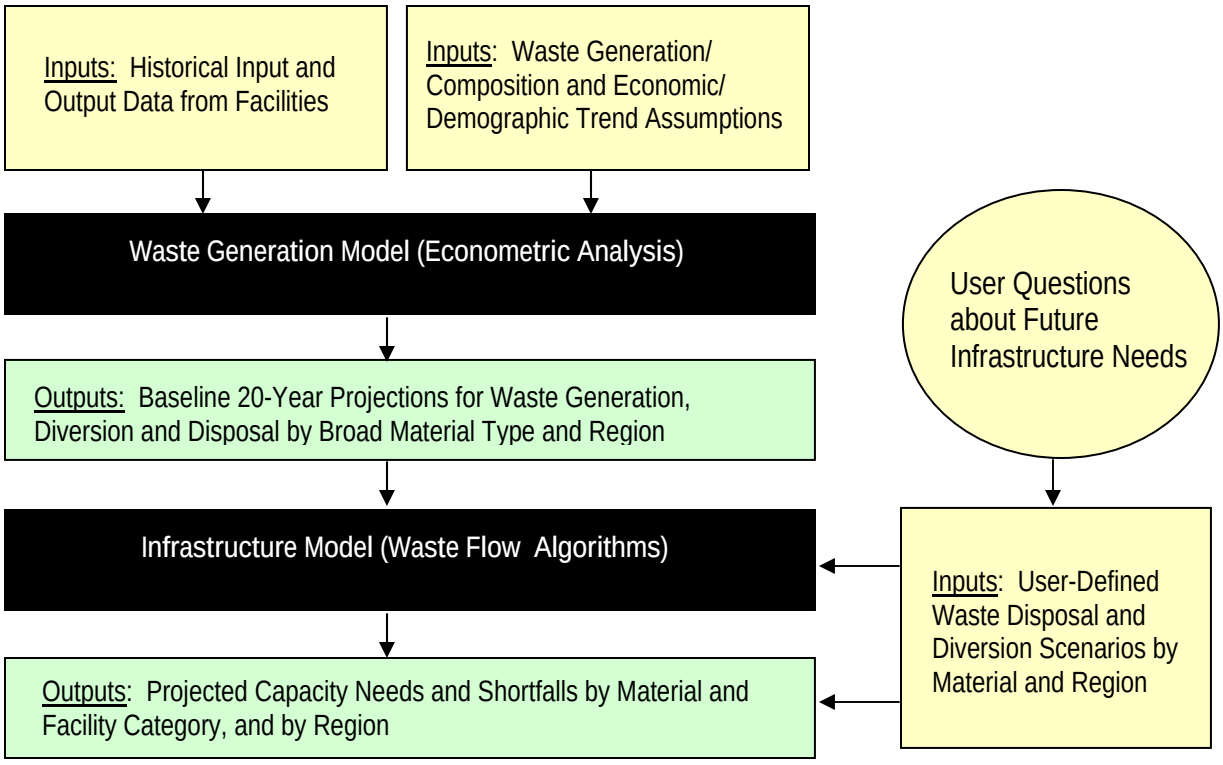
The sections below summarize the project team's preliminary approach to addressing five key modeling issues:

- What are the model's inputs and outputs?
- What kinds of questions can the model address?
- How will the model work?
- How can key modeling challenges be addressed?
- What are the main model limitations?

This preliminary approach will be refined based on stakeholder input and further evaluation of alternatives in early 2009. The completed Infrastructure Project Web Site is targeted for rollout in April 2010.

What Are the Model's Inputs and Outputs?

The purpose of the model is to project future waste generation, flow and infrastructure needs under a range of assumed scenarios. The following diagram provides a high-level overview of the model inputs and outputs currently envisioned. The yellow boxes represent inputs, the black boxes represent model calculations and the green boxes represent model outputs.



There are two main components to the model. The first component is the waste generation model which relies on econometric analysis, a systematic way to predict the future based on past trends and relationships. The inputs are historical data on quantities of each material category input and output from facilities, and assumptions about waste generation, composition, economic and demographic trends. The outputs are projections for waste generation, diversion and disposal quantities by county and/or multi-county region.[1]

The second component is the infrastructure model which relies on a set of waste flow algorithms, or equations, that describe how different categories of waste and recyclables tend to flow to different types of facilities. The inputs are assumed scenarios regarding the percentage of each waste category that is disposed or diverted by county or multi-county region. These user defined scenarios can be applied to address research questions as described below and indicated in the figure.

The project team will define a set of baseline assumptions for a 20-year planning period based on currently available data. Model users can then define alternative scenarios for one or more material categories by region or statewide. The outputs are projected infrastructure needs and shortfalls by facility category for the region and years defined by the model user. More specifically, outputs may include the type, number and size of needed facilities in specified geographic areas with summary reports providing aggregated "stack" graphics showing how waste management and recycling needs are projected to be met by different types of facilities or through export. Outputs will be presented in terms of broadly defined waste streams as described in Definition of Material Categories, but the model will be designed to be as flexible as

[1] Stakeholder feedback is requested in the on-line survey regarding how modeling regions should be defined.

possible, so that the Board can engage in updates to the model in future years as deemed appropriate.

What Kinds of Questions Can the Model Address?

The model will first be used to develop baseline projections allowing users to answer the following key questions:

- How much disposal and recycling tonnage is estimated to be generated, by County or Multi-County Region and Statewide, over the next 20 years?
- Given the demand for waste management and recycling infrastructure by material type, what regions of the state are projected to need new facilities, by type of facility?
- When will such facilities be needed in order to meet waste management and recycling demand, given the horizon of the waste generation projections?

Model users will then be able to define a range of different scenarios and compare them to the baseline projections. Each scenario will be comprised of new user-defined assumptions regarding the amount of waste disposed or diverted by county or region, and to a limited degree changes in assumed economic and demographic trends.

Because of the complexity of running the model and the need to carefully interpret results, we preliminarily envision that certain modules of the model will initially be available only to certain assigned Board Staff. However, the public will have access to the results of several different standardized or "canned" modeling exercises designed to address a range of useful standardized questions. Preliminarily, these questions may include:

- How would a specified increase or decrease in population over a certain time impact waste generation, diversion, and infrastructure capacity needs?
- How would a specified increase in the statewide diversion rate for certain material categories impact infrastructure capacity needs?
- How would a ban on use of selected materials as alternative daily cover impact infrastructure capacity needs?
- What would be the impacts on available composting infrastructure capacity if certain conversion technology facilities were sited?
- What are the infrastructure capacity implications of the current significant drop in export demand for certain material categories?

In each case, to address the questions above R. W. Beck will work with the Board to define the scenario in terms of either a specific disposal/diversion rate, a specific tons by year, and by material assumption, and/or specific adjustments to embedded assumptions in the econometric and/or waste flow model. The project team is seeking input from stakeholders on the types of questions and scenarios that should be modeled. To provide suggestions, complete the online feedback form.

It is important to note that certain combinations of scenarios may not be practicable as a function of the underlying model algorithms. For example, achievement of a 75% diversion rate by a certain date may necessitate that export markets not collapse. Therefore, it may not be possible for the user to simulate both scenarios simultaneously.

How Will the Model Work?

The details of the econometric model and infrastructure model will be presented for stakeholder review in summer 2009, since they will depend on the quality and quantity of available data. This section generally discusses our preliminary approach to addressing some key modeling challenges.

The first model component, econometric analysis, projects aggregate waste generation, disposal and diversion based on historical data and readily available population, economic, and demographic statistics, most likely defined at the County level. Existing data on historical disposal will be combined with information from detailed survey work undertaken as part of the infrastructure information survey effort, and historical and projected economic data as developed by a nationally recognized third-party provider. It is anticipated that recycling tonnage projections may be based on a recycling rate assumption that "imputes" recycling based on econometric disposal forecasts, and then sums such projections to arrive at total generation. Alternative methods based on modeling total generation will be explored to the extent data availability permits. At the conclusion of this phase of modeling, the projections of aggregate generation, disposal, and recycling will be converted into a material flow projection by combining the forecasts with the results of the most recent comprehensive waste characterization study conducted by the Board. The project team will review and incorporate, to the extent possible, existing approaches to waste generation estimation developed by the Board to avoid "reinventing the wheel". It should be noted that the waste and recyclable flow categories defined in the project may need to be revised based on modeling needs.

The second modeling component, infrastructure modeling, is based on relatively simple (though numerous) arithmetic algorithms that dictate how each material type flows, based on user-defined or assumed management profile scenarios and market condition assumptions. The flow of materials from a source to particular infrastructure facilities would primarily be determined by factors such as the average range of distance the material type is typically shipped, the characteristics of existing facilities that currently accept the material, the types and characteristics of potential new facilities that could accept the material, and the relative advantages of one management alternative over another (such as price, for example). In order to model infrastructure needs in an efficient way, information on average facility conditions (e.g., dimensions and capacity) will be solicited from survey respondents in an effort to construct boilerplate characteristics for each modeled facility. This will simplify the model output to be restricted to generic future facility additions.

This module would provide estimates of changes in what kinds of facilities are needed and a rough estimate of where they are needed (i.e., in geospatial terms relative to projected demand for waste management infrastructure) given the baseline or alternative material flow projection developed as part of the first phase of the model. Information critical to the development of these algorithms will be gathered as part of the broader infrastructure information survey, which will focus on a comprehensive attempt to understand current facility throughput and capacity, opportunities for capacity expansion, and estimates of currently planned future facilities, which will be taken into consideration as the algorithms are developed. The complexity of the algorithmic relationships will be a function of data availability.

It is anticipated that the model inputs, outputs and calculations will be housed primarily in a Microsoft Excel ® spreadsheet, with geospatial outputs related to infrastructure needs as

calculated by the model represented by circles accompanied by arrows on a Geographic Information System (GIS) layer.

Web site users will not have the ability to adjust the underlying model algorithms; however, the Board will have the ability to periodically reexamine and potentially revise the algorithms to reflect changing conditions and facility data. Facility data will likely be updated on an ongoing basis by facility owners/operators, as well as through periodic comprehensive data gathering efforts. Preliminarily, the project team is assuming these updates and review of model algorithms would occur once every two years, but this may be adjusted based on Board resource availability.

How Can Key Modeling Challenges Be Addressed?

Modeling in this project is subject to several key challenges and the table below summarizes the project team's preliminary approach to addressing them. Most importantly, modeling in this project is complicated by a general lack of historical data and by constant changes in material flows in response to changing facility ownership, contracted services, regulation, technology, pricing, competitive positioning and other factors. In some cases (e.g., waste paper or C&D) recyclers may choose on a daily basis, based on market conditions, whether to haul materials to a disposal facility or a recycling facility, or whether to adjust the level of processing to yield higher value grades. This market behavior increases the difficulty of gathering reliable historical data and means that infrastructure model results will always have a certain amount of uncertainty associated with them. Consequently, our technical modeling approach will conservatively assume a minimum amount of data availability. The approach and modeling assumptions will be refined as data become available.

Table 1 - Waste Flow Analysis and Modeling Challenges and Approaches

Challenge	R. W. Beck Approach
Lack of historical data, especially on quantities and flow of recycled materials, provides little basis for econometric or extrapolation-based algorithms.	Incorporate econometric algorithms based on historical data only where possible, probably restricted to waste generation prediction.
Dealing with data of uncertain accuracy and quality, validating data and eliminating double counting.	Develop data analysis QA/QC protocols to specifically look for and address these concerns, and define outputs as ranges where appropriate.
Dealing with data gaps.	Rely on estimates where justified and/or extrapolations from existing data. Validate based on observed conditions where possible. As appropriate, superimpose robust econometric algorithms derived from best data sets onto regions that lack adequate data.
Predicting waste flow and infrastructure needs given constantly changing market, technology, contractual and other factors.	Recyclables flows may be based on relatively simple (though numerous) algorithms incorporating assumptions about optimal shipping distance, typical import/export tailored to each material stream analyzed. Model results will include caveats and qualitative information describing key factors influencing variation, and certain results may be most suitable for use and interpretation by Board staff, not the public.
Developing a model that can address the range of scenario analyses envisioned in the RFP and potentially desired by stakeholders.	Establish clear priorities for independent variables defining scenarios to be input by users (probably based on assumed quantities flowing to different types of management options, e.g., landfill, recycling, and composting). Users will be allowed to vary key assumptions to meet a variety of research needs.
Finalizing baseline data requires judgment based on industry-specific expertise, making it difficult to rely solely on calculations and algorithms alone.	Consider recommending that the Board's ongoing protocol include hands-on involvement by industry experts.
In practice recyclable flows are determined by dozens of narrowly defined material grades that are too complex, fluid and costly to model in practice.	Work with the Board to define modeled material streams prudently, balancing the desire for detailed models with the Board's current and future budget and resources.

What Are the Main Model Limitations?

Following below is a summary of some of the key limitations model users should be aware of. We envision providing in the model outputs a concise, standardized description of model caveats, limitations and how to use results. In short, the model results are intended to broadly indicate the number and type of certain waste management and recycling facilities that will be

required under user-defined scenarios. The results are not intended to provide a level of accuracy required for facility development purposes.

Key limitations include:

- Data gaps and poor data quality are likely to limit the accuracy of results as described above.
- The constantly changing nature of waste flows means that modeling results must be viewed as best available estimates subject to future revision.
- The fact that users cannot model simultaneously certain scenarios, as noted above, limits to a degree the types of questions that can be addressed with the model.
- Model outputs are based on current assumptions, and should not be used indefinitely for planning without regular updates. Of particular importance will be updates of projections of economic activity, and updates to capture the most recent waste generation, disposal and recycling data by facility.
- The time and detailed development issues associated with expanding existing facilities and siting new ones is not reflected in the infrastructure needs results (although it is considered in projecting baseline facility expansions reported by facilities). Users must factor these in to projections on when *development* of new facilities must begin.
- The level of precision in the model with respect to regional capacity needs will be relatively high-level, and will not include specific site coordinates.
- Both the econometric projections and infrastructure needs algorithms are predicated upon certain relationships that have held true in the past continuing to hold true. To the extent such relationships change in the future, users and stakeholders should take care to revisit these relationships in order to continue to model a system that is as representative of reality as possible.
- The model does not consider significant changes to the types of available waste material in the market. It may be beneficial in the future to conduct recurring waste characterization studies and eliminate or add emerging types of materials to the material flow projections to ensure a representative waste flow projection comes out of the model.